The Heating and Ventilation of the Mansfield Schools and Churches.

BY

R. HARVEY REED, M.D.,

City Health Officer, Mansfield, Ohio; Secretary Ohio State Sanitary Association; Member American Public Health Association, American Climatological Association, American Medical Association, British Medical Association, National Association of Railway Surgeons; Honorary Member D. Hayes Agnew Surgical Society, of Philadelphia, Member Ohio State Medical Society, etc., etc.

A Lecture delivered before the Mansfield Lyceum, February 13, 1889.

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THE HEATING AND VENTILATION OF THE MANSFIELD SCHOOLS AND CHURCHES.

There are three leading combinations of chemicals that enter essentially into the welfare of the human economy, the absence of either one of which would soon result in death. The adulteration or impurity of either, or a reduction of the normal supply of either one, results in a proportionate injury to the living human organism.

These three combinations are air, water, and food. In previous papers read before this Lyceum and our City Council I have called attention to the importance of a bountiful supply of pure water, and our city authorities have practically demonstrated their appreciation of such a supply by investing the sum of $190,000 in securing a suitable water supply for our city, which requires an annual outlay of $5,700 to maintain, saying nothing of the interest on the capital invested in the plant, and yet no one complains, or would ever think of voting to abolish our city water works, which every person concedes to be an absolute necessity.

The importance of a bountiful supply of pure air is second to neither of the other two combinations that must needs be present in order to support human life, and from personal experience and repeated investigations the unwarranted neglect and miserly supply of this, the freest of all of nature's gifts to man, has led me, as your City Health Officer, to inspect the schools and churches

of our city, and give you an unvarnished report of their real condition as to heating and ventilation.

In warm countries, where there is little need of protection from the elements, and where open huts serve in place of the "hermetically sealed" houses in our more rigorous Northern climates, there is little need of systems of heating and ventilation, for there the native or his visitor gets a bountiful supply of God's free pure air night and day, winter and summer, unmolested by the conventionalities of art. Not so in our Northern climates. The open hut is replaced by the device of the city architect, who at once commences to rob our people of their pure air, and study how they can build all sorts of fancy structures of the latest and most approved style, in which they can "hermetically seal" their inmates from the oceans of pure air that surround this "human can they call a house," and thus not only starve them of oxygen, but poison them in their own excrement—the carbonic acid gas they exhale from their stinted lungs at every breath. Could the dead that lie in yonder grave-yard, who have fallen victims to illy planned and improperly heated and ventilated dwellings, lift their voices in one accord against the architects who by their mistakes have forced them to a premature grave, nothing but an Ashland County jury would save them from conviction of murder in the second degree.

In making these inspections I have endeavored to "hew to the line, let the chips fall where they may." I have inspected all the churches, and each room in every school-house in the city, in person, and noted the exact plan by which it is heated and supplied with pure air, or air of any kind, and have tried to briefly point out their faults and also note their good qualities, and

will close the paper by giving you a simple, yet scientific method, illustrated by charts and practically demonstrated by a model, whereby you can heat your buildings thoroughly, and at the same time flood them with abundance of pure air.

Before giving the details of these inspections, it is only just that I should say that in the main the people are not to blame for the almost universal defects found in the heating and ventilation of their schools and churches. They are not expected to know, nor to study up those problems, and most naturally depend on the architects for all the plans and specifications regarding their buildings, and hence they are just the persons the sanitarians are looking for, and *to* whom and *of* whom they have a word to say. The architect comes to you with a beautiful perspective, every inch of which is elaborately detailed down to the tacks and paint. So much must be stone from Cleveland, Cincinnati, or New Hampshire; so much must be brick of the latest pattern, burned with *hickory wood*; this particular part of the edifice must be finished with boards cut from the cedars of Lebanon, that part must be furnished with choice butternut from the valleys of the Mohican, the windows must be dappled with glass of many colors, the walls ceiled in with the best of plaster, and furnished with a specially hard finish; the floors must be of the finest oak, inlaid with hard woods of many kinds and colors; and finally this great and costly mansion is to be heated according to the latest and most approved methods.

That is usually all that is said and about all that is done in regard to supplying you and your family with the real necessity of life—the most important part of the whole edifice. I mean to say that the average architect pays little or no

attention to the heating and ventilation of your building. He can tell you all about the ornaments and fancy fixings on the cupolas and cornices of your house, and will insist that they be mathematically correct, yet the heating and ventilation, on which depend your life and health, he leaves to some furnace peddlar to complete "in the latest and most approved manner."

Go with me now, if you please, for a few moments, while I take you from church to church, and school-house to school-house of our prosperous city, and examine into and study from a practical and scientific standpoint the legacy the architects have left this city in the way of heating and ventilation in a class of buildings that should be the pride of every city and above all other public buildings the very type of perfection.

On December 18, 1888, I visited and examined the St. Luke's Lutheran church, which is not yet completed, and which was planned by an eminent architect, Mr. Wm. Gibbon Presto, of Boston, Mass. I found the church was heated by two Ætna soft-coal furnaces, made at Springfield, O., which are supplied with cold air from two windows leading into the coal rooms in the basement, over which the air must pass before entering the heater. The lecture-room of the church is heated from these furnaces by hot air, which is conveyed in conduits coming in from 4 to 7 feet from the floor. At the rear end of the lecture-room is a fire-place, and just beside it a foul-air register near the floor and opening into the furnace at that end of the church. At the front, or pulpit end of the lecture-room are foul-air ventilators located about 3 feet from the floor and opening into conduits that pass through pillars near the pulpit in the auditorium and open into the garret, which connects with the open tower. The one of these

passes a part of the distance near the furnace, which aids some in warming its contents of foul air, and thus assists in its upward movement, while the other is not provided with any means of heating whatever. In the auditorium the warm air comes in at the floor, while the foul air is allowed to escape by means of registers placed about 3 feet above the floor and opening into the attic, with no provisions for heating the column of cold air and thus favoring the exhaustion of the foul air from the main room.

REMARKS.—With no provisions for protecting the pure air from the dust of the coal and the ashes of the furnace it begins to get fouled before it enters even the hot-air chamber of the heater, and is an excellent method to carry quantities of dust into the rooms to be heated and ventilated. Whilst the lecture-room receives a pressure of warm air from the furnace the fire-place in the rear end of the church furnishes a most excellent method for the escape of the stratum of cold foul air that always finds a place at the floor, and it should always be kept burning when the room is being occupied. The foul-air ventilator that opens into the furnace should never be left open after the room is once heated, and under no circumstances when occupied by an audience, as that only serves to convey the *cold foul* air back to the furnace to be reheated and returned in all its impurity to be breathed over again by the audience. The other foul-air registers should have been placed at the floor, instead of 3 feet above the floor, and supplied with means for heating the column of cold air contained in them. As it is, they leave a three-foot stratum of cold foul air in the rooms they are intended to ventilate, even when the ventilators work. But you must remember they will not work until there is a sufficient pressure of air from

within to lift the cold column of air they contain, and if that is at any time greater than the pressure within, they will allow their contents to descend into the room to the discomfort of the audience.

In the lecture-room, however, the fire-place when in use serves this purpose as far as it goes, and not unfrequently creates such a draft as to cause the cold air to descend in the foul-air ventilators to supply and equalize the vacuum thus induced, especially when the supply from the furnace does not equal the amount of air exhausted by the fire-place. It must be remembered that a grate with a fire in it, and foul-air flues without fire, will not work harmoniously in the same room at the same time; hence one or the other, as a rule, should be closed.

On December 26, 1888, I examined the Baptist church, which was built in 1864, but by whom it was planned I was unable to learn at this time. I found it was heated by a Ruby soft-coal furnace, which was supplied by fresh air from the outside by two 8x8 inch cold-air conduits, whilst the warm air was admitted into the auditorium by five registers placed in the floor near the rear end of the room, to which the warm air was conveyed by five 10-inch hot-air conduits. Two foul-air registers were placed in the floor near the front end of the auditorium, one on either side, and connected with a conduit that returned the cold foul air to the furnace to be reheated and returned to the room again. These, however, had been abandoned some time since and closed up. Two 14x16 inch registers were placed in the ceiling, which allows all the warm pure air to escape into the garret, while the cold foul air is allowed to remain in the lower portion of the room. The janitor, however, has discovered that in order to heat and

keep the auditorium warm he must close these registers, which serve him well when the room gets too warm and he desires to cool it off rapidly.

REMARKS.—By enlarging the cold-air inlet of the furnace, and opening the foul air ventilators at the floor into the two chimneys at the front end of the church, which are always kept warm by stoves, a very great improvement could be had at a minimum amount of expense in the way of heating and ventilating the auditorium. The lecture-room is heated by stoves, with no provision for either the ingress of pure air or egress of foul air, except by the windows, which needs no comment at this day and age, as a means of ventilation, as they are always an objectionable means of obtaining fresh air, except in very warm weather.

On January 10th and 11th, 1889, I inspected the Congregational church, which was built during 1871–3, at a cost of nearly $125,000, under the direction of architect G. P. Randall, of Chicago, Ill. The auditorium is heated by steam from coils of pipe running under each seat, which furnish ample means for the desired amount of heat. The original plan provided for seven large ventilators placed in the comb of the roof and leading down into the top of the auditorium, and so arranged by valves as to be opened or closed at will, whilst the foul air was expected to beat a hasty retreat through two small registers, 12x12 inches, placed in the base-board of the auditorium and opening into the cellar.

By this theoretical plan it was intended to let the fresh air in at the comb, which being cold and consequently heavier, would descend into the auditorium, driving the foul air out at the floor into the cellar. But, like the old spook story of

our childhood, when a certain boy undertook to scare another lad while he was passing through a certain piece of timber land, it was a failure. Having secured a sheet he placed it over his head and lay in wait for his victim. But a pet monkey decided to imitate the performance, and, unseen, followed his master to his hiding place, with a pillow-case over *his* head. Just as the victim approached, the trickster chanced to spy spook No. 2, and instead of scaring his victim, became frightened himself, and started to run with all his might, followed by the monkey, while the victim enjoyed the fun and egged on the race by shouting, "Run, big spook, or little spook will catch you."

So in this method of ventilation, instead of the fresh air coming in at the comb and supplying the auditorium, the warm air rushed out, and instead of the foul air passing out through the little registers at the base-board, the cellar air rushed in, and we had a reverse order of affairs throughout, as in the old spook story. These are only the result of natural laws, however. The warm air being lighter rises and escapes through the comb ventilators, there being no provision made by the architect for a supply of fresh air a vacuum is the result, and the equilibrium is established by the cold air rushing in from the cellar through the foul-air registers, as well as through the doors and windows. The janitor, however, found it impossible to heat this room with the comb ventilators open, and in order to accomplish his duties satisfactorily, closed them and supplied the auditorium with fresh air by means of doors and windows.

The lecture-room of this same church is heated by stoves, and has no supply of fresh air, except through the doors and windows, whilst the warm

air is allowed to escape, as usual, at ventilators placed near the ceiling, and the foul cold air is allowed to remain at the floor for the benefit and edification of the audience.

Remarks.—It is no doubt plain to every one here to-night that the heating and ventilation of this church is a practical failure. It is true you heat the church, and, as managed by the janitor, you get some fresh air from promiscuous sources, and allow a part of the foul air to escape, none of which can be credited to the original plan, which in and of itself cannot be recommended as a desirable method of heating and ventilating.

On January 15th, 1889, the First Presbyterian church was inspected; it was built in 1858, but by whom I am unable to inform you. This church is heated by two Montrose hard-coal furnaces, which are supplied with a small quantity of fresh air from the outside, but the mechanism of the furnace is such that the air is frequently contaminated with gas and dust, and always so overheated as to make it very disagreeable to inhale. The provisions for ventilating the auditorium are a few small ventilators, placed near the ceiling, which permit a quantity of the warm air to escape and leaves the carbonic acid near the floor to soothe the innocent audience to sleep while they may be trying to listen to the most interesting sermon. Hence the objectionable method of window ventilation must be resorted to as the less of two evils, to relieve the so-called "closeness of the air" and stupor of the audience from the poisonous effects of large quantities of carbon dioxide. The lecture-room is heated by direct radiation from the same heaters, and has no system of ventilation, except the windows and doors.

Remarks.—In this case it is plain that the church is improperly heated and is devoid of any-

thing like adequate ventilation, whilst large quantities of coal are wasted annually in trying to make the church approximately comfortable.

The St. John's German Evangelical church was visited and inspected January 18, 1888. This edifice was built in 1870, and is heated by a Barnes' soft-coal heater, No. 64, which secures its supply of air from the Sunday-school room, which it heats by radiation, and this air, after being vitiated by the Sunday-school scholars, is heated and conveyed to the auditorium in a second-hand condition for the congregation to use during the sermon. No provisions are made for ventilation except by windows in either the auditorium or Sunday-school room.

On the same date I visited the St. Peter's Catholic church, a handsome edifice, built in 1870; this is heated by stoves, and has no provisions for ventilation except the doors and windows.

REMARKS.—The congregation is a large one, and the architectural finish of the interior of the church is very costly as well as attractive, but the supply of pure air for the hundreds who congregate there from day to day has been wholly left out of consideration except by the faulty method of window ventilation.

On the 21st of January, 1889, I visited the Episcopalian church, which was built in 1847, and has had some repairs since that time. It is heated by one Crystal furnace, manufactured at Troy, N. Y., and one Sayer furnace, made at Montrose, Pa. The former takes its cold air from the cellar, which is in quite a dilapidated condition, and is in turn supplied by a hole in the wall on the west side of the church. The Sayer furnace is supplied with cold *foul* air from the rear of the auditorium, whilst the pure air from outside is carefully avoided, except so much as may

steal into the foul air register from the outside door of the church. There are no other provisions for ventilation except the doors and windows. The Sunday-school room, built two or three years ago, is heated by stoves, and ventilated by the door and window system.

REMARKS.—In the one furnace the impurities of an old and musty cellar are conveyed with the air to the furnace, heated, and forwarded to the auditorium, while the other furnace is employed to reheat the foul cold air of the church and return it to the unsuspecting audience to be breathed over and over again during each service.

The same day I inspected the United Presbyterian church, which was built in 1885, and planned by Richard Vaux, of New York City.

It is a handsome, well-arranged edifice, heated by two hard-coal "Richmond Triumph" furnaces, Nos. 30 and 27, built at Norwich, Conn. More care than usual has been observed with these furnaces, to exclude all the pure outside air possible, and instead the one is supplied with cold foul air exclusively, taken from the auditorium, reheated, and returned to the audience, while the other is supplied with air from the hall leading off the main hall to the lecture and Sunday-school rooms. Owing to the necessity of having the front door open as the people come and go, a small supply of outside air finds its way to this furnace at the opening and closing of each service.

REMARKS.—By means of openings in the ceiling and the opening of windows at the top, they are enabled to retain a large quantity of the cold foul air near the floor, and allow a great and unnecessary waste of the warm pure air through these openings. If the church authorities would close all the top openings of their rooms, keep them closed except when they desire to cool their

church, supply the furnaces with fresh pure air from the outside, empty their foul cold-air into the ventilating flue instead of heating and returning it to be breathed over again, they would find a reduction in their coal bills, and a large decrease in the drowsiness of their congregation when confined for any length of time in the auditorium.

On January 21, 1889, I examined into the heating and ventilation of the Methodist Episcopal church, which was built by Mr. Hershiser, of this city, about 1868. It is heated by two hard-coal furnaces. One is a No. 5 Sayer furnace, built at Montrose, Pa., and the other is without name, so far as I could see, but is much like the Sayer heater. The former is placed in the library, and when the library window is open, it is supplied with fresh air from the exterior of the building; but when the window is closed, it is without a fresh-air supply, and must draw its air from the library and lecture room with which to supply the auditorium. The other furnace is supplied with fresh air by a conduit about a foot square, which receives its supply from the outside by means of a window. There is no provision whatever for the escape of foul air from the auditorium except through the doors and windows. Two small registers have been placed at either side of the auditorium on about a level with the tops of the windows, which allow quite a quantity of the *warm pure-air* to escape, and thus aid in cooling the room and wasting the fuel. The lecture room must depend entirely on door and window ventilation for the purification of the air.

Remarks. — By changing the registers and placing them at the floor, making them several times larger, and supplying both furnaces all the time with fresh air from the outside of the church,

the auditorium could be very greatly improved with regard to its heating and ventilation.

The Christian church was examined on January 22, 1889. The erection of this church dates back to a period before the civil war; the exact date I was unable to obtain. It is heated by a Sayer furnace No. 5, supplied from the floor of the auditorium with *cold foul-air*, which is allowed to escape through a register in the floor at the west side of the church; this connects with a cold air conduit coming from the exterior of the edifice to the furnace. No other provisions have been made for the escape of the foul cold-air except the doors and windows.

REMARKS.—In this church we have a mixing of "good and evil," as it were. So far as supplying the furnace with air from the outside is concerned it is good, but when it comes to contaminating the same with vitiated air from the auditorium, it is evil. The vitiated air should be conveyed to a ventilating flue and allowed to escape.

On January 22, 1889, I visited the Evangelical Lutheran church, which has been recently repaired. This structure is heated by two "John Grossius" soft-coal heaters, made in Cincinnati. The Sunday-school room is heated by radiation, and ventilated by doors and windows only. The auditorium is heated by fresh warm air, which enters the room by means of registers in the floor. There is no provision for the escape of foul air except by the doors and windows. An opening in the garret is in the interest of the coal dealers, as it necessitates the use of more coal to heat the church, owing to the great loss of warm air, whilst the corresponding increase of carbonic acid keeps up a slow process of poisoning the audience.

On the same day I visited the English Lutheran

church, which is an old-style edifice, built in 1856, and soon to be replaced with a new one.

This building is heated with a Sunbeam Challenge furnace, from New York. The furnace is placed in the lecture room, which is heated by radiation, and ventilated by doors and windows, while the auditorium is supplied with foul air taken from the lecture room, and heated and sent upstairs. There is no provision for the escape of the foul air except through the windows and doors of the auditorium, which is supplied with a sort of a safety-valve attachment in the way of a trap door in the ceiling, which is very convenient to waste the surplus heat of the room when the pressure gets too high.

On January 22, 1889, I visited the church of the Believers in Christ, which was planned by the pastor, Rev. Sorg, and built in 1887. This plain but neat little edifice is heated by a Montrose furnace and supplied with fresh air from the exterior of the building by means of a 15-inch vitrified pipe conduit. The foul air is removed from the lecture and Sunday-school rooms and auditorium by means of four foul-air registers placed at the floor and opening into the ventilating shafts. The auditorium is also supplied with four additional registers, placed near the ceiling, which are only used to cool the church when it gets overheated.

Remarks.—I cannot pass this building without congratulating this congregation on the advancement they have attained over all the other churches in the city, with perhaps one exception, in regard to the heating and ventilation of their building.

On January 24, 1889, I examined the Associate Presbyterian church, which is a very small edifice, built in 1888; it is heated by stoves, and ventilated by doors and windows. Four 12 × 12 inch

registers have been placed in the walls near the ceiling, and are only mentioned to be condemned, except for cooling off the church when it is overheated.

On the same day I inspected the Reform Presbyterian church, which was planned by a Mr. Rumbaugh, then of this city, and built in 1885. This church is heated by Goff & Co.'s hard coal, hot-air, blast furnace, which takes the fresh air from outside the church, heats it, and delivers it to the auditorium at the floor near the rear of the room, while the foul cold-air is taken from the front and lowest part of the room, and exhausted by means of a foul-air shaft, which is heated by a small stove used in one of the side rooms of the church. In the foul air conduit is an arrangement by which the cold air can be turned into the fresh-air conduit leading to the furnace. This is used only while heating the church, when it is cut off from the furnace and again opened into the foul-air shaft, which is or should be kept open during the presence of an audience in the auditorium. The Sunday-school and lecture room is heated by a Grossius heater, manufactured in Cincinnati, and is supplied with fresh air from the exterior. Unfortunately, however, there was no provision in this room for the escape of the foul air, except by the doors and windows.

Remarks.—With the exception of the Sunday-school room, the system for heating and ventilation used in this church is the best in the city, whilst the Sunday-school room could easily be remedied by placing a foul-air register in the ventilating shaft of the chimney.

It will be observed that, with two exceptions, there is not a church in our city that is provided with adequate means for the prompt removal of

the carbon dioxide, the deadly poison that is exhaled with every breath. When we remember that it requires at least 1,500 cubic feet of pure air every hour to supply one human being, and when we know that the average movement of air through a conduit of 1 square foot capacity under ordinary circumstances, in mild weather, is about 150 feet a minute, and again take into consideration the miserly holes that are required to do this duty in supplying the majority of our churches, we are not surprised that people get sleepy when they attend church. It would be just as reasonable for each congregation to elect a committee annually, whose duty should be to give each member a dose of morphine every time they enter the church, in order to stupefy them during the sermon, as to allow the ventilation of their churches to remain as they are, and poison their members with a drug that is even more dangerous than any of the modern narcotics, to say nothing of the disgusting and filthy custom of breathing and rebreathing the foul exhalations of their neighbors.

I have no doubt this lecture has already reached proportions that may weary some of you at least, but the importance of the subject is such as justifies me in trespassing still further on your patience, and hence I have left the most important part of our topic for the last.

When we remember that the youth of our city spend the best part of their days (from 7 years to 21 years) in our school-houses, and that among them is your daughter or my son, whose life and health depend on the perfection of their sanitary conditions and surroundings, it is sufficient excuse for our dwelling longer on this subject, and examining into their real condition and merits from a strictly sanitary standpoint. I shall try, however, to group them, and thus save time and space.

The first two school-houses examined were the Marion Avenue and John's Addition (new building). Both of these buildings have just recently been constructed, and were planned and built by Mr. F. D. Webber, of this city. As they are practically heated and ventilated on the same plan, I will consider them together in order to save time.

Each room is heated by a Grossius soft-coal heater, placed in the room to be heated, and supplied with cold fresh-air from the exterior of the building, conveyed to the heater by a tin conduit some 8 or 10 inches in diameter, with a perforated diaphragm placed near the exterior opening to lessen the amount of air admitted. This air passes through the hot-air chamber, and out at the top of the stove into the room. A number of foul-air ventilators are placed in the base-board at the floor, which the contractor informed me opened into the space beneath the floor, and from there into the foul-air shaft. These registers at the floor are 15 × 5 inches with one exception, which was 12 × 10 inches, and placed in the baseboard near the floor, and opened directly into the ventilating flue, which was warmed by the chimney.

Remarks.—In the first place, the fresh-air supply was entirely too small for the number of pupils contained in each room, to give them the required amount of air, and the result was I found the teachers were in the habit of raising the windows to admit fresh air, at the expense of some unfortunate child taking cold from a draft, or being uncomfortable to say the least.

In the second place, I found that almost invariably the cold air was coming *in* at these foul air registers, placed around the room at the floor, instead of going *out*, except the ones opening into the ventilating flue direct, in which there was a

strong outward draft. This fact necessitated the keeping of these closed, as they made the room very uncomfortable when left open. I think we can attribute the failure of these ventilators to work as designed to three possible causes:

First, that their size is too small, and the space between the floor and the ceiling is not sufficient to favor an outward draft.

Second, that the ventilating flue into which they emptied was too small, or not sufficiently heated to establish a draft under the circumstances, and

Third, that the supply of fresh air was not sufficient to supply the exhaust through the direct ventilator and the open transoms above the doors, and at the same time produce a draft through under the floor.

Whilst these two buildings are the best ventilated school-buildings in the city, yet I would recommend more fresh air, which should not be heated so hot while passing through the hot air chamber as it now is, and either no ventilators opening into the space beneath the floor, or if there are, to have them larger, with more space beneath the floor, with a well heated foul air shaft in order to secure a constant and perfect exhaustion of the cold foul air. As the buildings now exist, I would close all these floor ventilators except the one opening into the ventilating shaft direct, and make that one opening into the foul air flue at least two or three times larger. Whilst this would not secure perfection in heating and ventilation, it would be a vast improvement on the present, and avoid the dangerous and unsanitary habit of opening the doors and windows to obtain fresh air.

On the same date (January 22, 1889) I visited and examined the High School building, and on the 23d the Fourth Ward building, which we will

consider together, as they are both heated and ventilated on the same plan. These buildings were erected some fifteen years ago by Mr. Hershiser, of this city, who put in a Boston system of ventilation. The rooms were all heated by a Grossius heater, supplied with fresh air from the exterior, while the foul air was *intended* to be removed by small registers, 18 × 4 inches, placed in the baseboard at the floor, and opened into a 3-inch or 4-inch tin conduit that descended into a 6-inch tin conduit placed beneath the floor, and which finally opened into the ventilating shaft.

REMARKS.—The same remarks hold good in regard to these buildings as to the former as regards their fresh-air supply, and the system of getting rid of the foul air is a total failure. Excepting the little ventilators that open directly into the ventilating shafts that were warmed by the chimney, there was no outward draft whatever, whilst in many of them that opened into a cold ventilating shaft there was a strong current of cold air coming in, which kept the floor cold and uncomfortable. The same recommendations would apply to these buildings as to the former ones, which we are certain could still be improved by having furnaces placed in the cellar to supply the necessary amount of fresh air properly warmed, and thus avoid the necessity of carrying the coal up stairs and delivering it all over those large buildings as is now the case, saying nothing of the increased danger of fire by so many stoves.

On January 22, 1889, I examined the old school building in John's Addition, and on the 23d the old Normal School building, which we speak of only to condemn. They are both heated by stoves, with no provisions for fresh air, or the escape of the foul air, except at the doors and windows. In these buildings the air was almost intolerable, and

the sooner they are condemned for school purposes the better it will be for the rising generation that must now be incarcerated in them from day to day.

The Second and Third Ward buildings were examined on January 23, 1889. Both were heated by the Grossius heater, which was supplied with fresh air from the exterior the same as the other buildings already described. In the old part of the Third Ward building the foul-air ventilators were placed at the floor as in the former buildings, but opened into the hollow wall, instead of a ventilating flue, which connected them with the garret. Some of these ventilators were working all right, but the majority were admitting *cold* air, instead of exhausting the foul air. In this building there were no ventilators opening directly into foul air shafts. In the new part of this building there were no foul-air ventilators at the floor, but a retrograde metamorphosis had apparently been established by placing three ventilators in the wall near the top of the room, whereby the foul air was left in the room, and a large portion of the warm pure air wasted.

In the Second Ward school building the new part has a foul-air register up stairs, 18 × 12 inches, opening into the hollow wall near the chimney, whilst the old part has no foul-air ventilators at all, and no registers, except some in the top of the room which, as usual, waste fuel by cooling the room and leaving the foul air in it. I found one 8 × 10 inch ventilator opening into the smoke flue at the floor up stairs in one of the rooms, while some of them were not provided with any kind of ventilation except the already so frequently condemned door-and-window ventilation.

On the same date we examined the last one of the city school buildings, located in Newman's

Addition, which was built some ten years ago, and was heated by a Grossius heater, and supplied with fresh air from the exterior as usual. In this building there was an opening in the ventilator in the cellar, which very much interferes with its duties in the school-rooms, where it was most needed. In the lower room a foul-air register opened into the ventilating flue at the floor, but was so filled with dirt as to completely stop all exit of air through it. In the same room were a few small registers placed back of the teacher's stand, and located about halfway between the floor and ceiling, thus allowing the warm air of their room, with as much of the foul air as chanced to rise that high in the room, to escape, whilst from these to the floor was a 5 or 6 foot stratum of foul air which had no means of escape, and which was additionally cooled by reverse drafts of cold air which invaded the room very frequently through these upper ventilators. The up-stairs department was heated and ventilated on practically the same plan, which resulted in the teachers having to depend on window-and-door ventilation for their pupils.

In all these inspections, in which I was assisted by our worthy Superintendent of Instruction, Prof. Simpson, while examining the school buildings, you will observe I have examined fifteen churches and nine school-houses, every one of which I visited in person, from the cellar to the garret, and examined carefully their systems of heating and ventilation, and when necessary actually tested the drafts and currents of air by proper methods, to satisfy myself of their exact course; and whilst a few of them are fair, I have failed to find a single one complete, and the majority of them are simply horrible!

The question now most naturally arises after

all these examinations, How shall we completely heat and ventilate our public buildings? In answer to this question, I will say there are three prime factors that must be duly considered. They are:

1. Uniform heating throughout each room.
2. Abundance of pure air for every person.
3. Prompt removal of foul air from each room.

Then, after having secured these, there are four other factors that must not be neglected. They are:

1. Safety.
2. Economy.
3. Durability.
4. Simplicity.

Having taken it for granted that we have secured *all* these, we will now proceed to answer the question of "How shall we completely heat and ventilate our public buildings?"

By a series of colored charts, and after having shown you the faults of your public buildings, I will continue to illustrate the complete plan, which involves the correct scientific principle of heating and ventilation, by the aid of these charts. Having done that, I will endeavor to confirm my statements by a practical demonstration of both the true and false principles of heating and ventilation by a model house. Before we take up the charts, permit me to say that in a properly heated room there should not exist in any part of the same room a difference of over 5° to 10°, including the ceiling and the floor.

Provisions should be made to admit at least 1,500 cubic feet of air every hour for each occupant of a given room, which can easily be calculated when we know that on an ordinary calm day about 150 feet of air passes through a conduit one foot square in a minute, or in other

words, 9,000 cubic feet, or just enough for six persons for a single hour. In addition to supplying the pure warm air to a room, there should be ample means for the prompt removal of all the foul cold-air, and under no consideration should the carbonic acid be allowed to exceed (and continue at that point) 10 parts in 10,000 of air, and much better if it is prevented from exceeding 5 parts in 10,000, especially in our school rooms. But the real facts are that it is seldom kept so low as 10, and often reaches 20 parts, and even more, to 10,000 parts of air.

If you will turn your attention to these charts, which have been carefully prepared from practical results of a long series of chemical and thermometrical investigations, and show the average relative purity of the air, as well as the temperature of the same, under the various systems of heating and ventilation they represent, you will, perhaps, more fully understand what I desire to make plain to every one here to-night.

In chart No. 1, you will readily recognize a familiar every day picture of the mother at her ironing, with a red-hot stove near by, and a window near the stove, let down from the top, through which is escaping a volume of hot air at the upper part of the opening, while a stratum of cold air is pouring in at the lower part of the opening to supply the vacuum produced by the escape of the former. From the lowered window of the leeward side of the room is a constant volume of cold air rapidly descending to the floor, and at the same time keeping that side of the entire room cold by forcing the warm air to the opposite side of the room. The mother's face is flushed with the heat from the stove and the exercise of the ironing, for which reason she has just opened the window to get a breath of

fresh air, as she terms it. While the upper portion of her body is too warm, her feet are cold, and at the same time her little child is crying with the cold as it tries to play on the floor around her feet; and yet that mother goes to bed with a cough, and her child suffers with catarrhal trouble, and she "can't for the life of her see how it comes."

Only last Saturday I was visiting a child with congestion of the lungs, and lying in a cradle near the floor. I remarked that the room was not warm enough for it, when they promptly pointed me to the thermometer that was hanging about six feet from the floor and registered 72° Fah. I laid the same instrument on the floor beside the cradle for ten minutes, and showed then it registered 56°, or a difference of only 16°, and yet they were surprised that their child had been taken sick, for they were sure it had never been out of the house or exposed in any way to the cold.

Chart No. 2, represents the good old-fashioned grate "of ye olden times," when a man never lacked for exercise while trying to keep warm by it, for just as fast as he got one foot warm by crossing his legs and holding his foot up to the fire, his other foot would get cold, and he would have to change off and warm that, and at the same time while his face was flushed with the heat, the cold chills were playing up and down his back until he must turn that to the fire, when the other side would get cold; and thus he must ever turn like the spit before the fire to keep warm. You will readily see by this chart that it divides the room into two triangles; as the rays of heat travel in direct lines and the heated air rises, the natural consequences are that the side of the room next to the grate is warm from the

level of the fire to the ceiling, while the opposite side is cold almost from the ceiling to the floor. You will see that each one of these form the perpendicular of a triangle ; while we have a cold floor on the one hand, and a warm ceiling on the other, forming the bases, and a direct line from the fire to the opposite upper corner of the room forms the hypothenuse that divides, as it were, the cold foul-air of one-half of the room from the warm air of the other. It is no longer a question that the fire-place alone is a very defective method of trying to heat and ventilate a room.

We will now pass on to chart No. 3, which represents an attempt at heating a room without stove or grate. In this case the architect has decided to heat the room with warm air admitted at the floor in the centre of the room, and in full accord with the old theory that the foul air *rises*, he has decided to permit that to escape at the top of the room, just as I have found to be the case in several of our school rooms and churches in this city. Indeed, I am sure you would be surprised to find how many intelligent people, even at this day, will appear to be thunder-struck when you tell them the warm pure air is at the top of the room, and the foul cold air at the bottom of the same. Only a few days ago I met a gentlemen who still contended that such was the case, and insisted on not being reconciled to believe anything else. I asked him if he had ever made or saw made any chemical analysis of the air of various rooms? He said, "No." I then asked him how he knew that he was correct? He replied, "Why, because the physiology says so." That is the secret of the whole business. Some person said so, and hence, it must be so, whether it is so or not, and the general result is that no person takes the pains to investigate the

facts and correct the popular mistake, and consequently custom has to some people made a law.

You will see by this chart that like the smoke from the fire in the Indian's tent, the heat arises to the top of the room and out of the first opening it finds, and if the exit is equal to the inlet, the remainder of the room continues cold, and the foul air it contains remains unmolested. In trying to overcome this the architect has decided to change the plan of ingress of the warm air to the opposite lower side of the room from the place of exit at the ceiling, with a view of making the warm air travel a greater distance through the room, but the improvement, as you will see by chart No. 4, is so slight, and the results so unsatisfactory, that he must seek some other method in order to accomplish his ends, and warm the room and remove the foul air.

In chart No. 5, you will observe he has, in part, accomplished this by lowering the place of exit, and just in proportion as that is lowered, the portion of the room above is heated and ventilated, while that portion below is imperfectly heated and contains a stratum of foul air. You will remember I called attention to this fact in my report of the conditon of the St. Luke's church, of this city, which has its foul-air registers placed some three feet from the floor, and in consequence will leave an equivalent stratum of foul air in the room. You might just as well set a barrel on end and try to empty it by boring a hole, say a foot from the bottom. Of course, the water would all run out to a level with the bottom of the hole, which would leave a foot of water remaining in the barrel. The same is just as true of cold foul-air in a room.

In chart No. 6 the sanitary engineer has solved the problem and placed the inlet and outlet of the

air both at the floor. The warm pure air is taken in at the floor and the foul air is removed at the floor at the opposite side of the room, and the consequence is that the entire room is heated and ventilated evenly throughout. That this method of heating and ventilating a room is a success is beyond question, and if there is a single person in this audience here to-night who questions its practicability, all I will ask him to do is to come to my house and I will show him the whole system at work in my own house, where it has proved successful beyond a question, and, besides, has very greatly diminished my coal bills, over the old plan of top-ventilation, which preceded it in the same house, besides supplying each inmate with over 1,500 cubic feet of warm pure air every hour, and removing the foul air to a standard not exceeding 4 or 5 parts in 10,000 at any time, day or night. Perfect as this plan is, it has still been improved upon, not in the way of ventilation, but in the economy of fuel and the comfort of the floors, by running the cold foul air through registers placed just beneath the windows and opening into the space beneath the floors, and from there into the foul-air ventilator, which warms and dries the floors, and thus is a saving on the fuel by causing this partially warmed air to pass through under the floor before it escapes up the ventilating shaft.

This ingenious and economical method of heating and ventilating was suggested and put into practice by that veteran sanitary engineer, of Toledo, Ohio, Mr. Isaac D. Smead, who has done more to develop and perfect the true scientific principles of heating and ventilating buildings than any one man on this side of the Atlantic Ocean, if not in the world.

As the old saying is, "Seeing is believing,"

hence before closing this lecture I will show you, by the aid of this model house, beyond a question that the principles I have endeavored to impress upon you are correct and based on scientific facts. You will observe that this is nothing but a tin box, made air tight, in the shape of a house, with a glass front in it. Here at this end is an opening at the floor to admit fresh air. At the opposite end is an opening at the floor leading into a chimney or ventilating flue, just as a fire-place or grate would. At the top of the room are six openings to represent windows. Now I will take this small wax candle, and from an opening in the floor I will place it in the lower part of the room near the floor and close the opening I will now close all the windows and just leave the opening at the floor for pure air and the other opening at the floor for the escape or foul air, open, and you will observe the candle burns brilliantly and uninterruptedly, or until it is consumed.

I will now close the exit for foul air at the *floor* and open all the six windows at the *top*, and you will find that the candle will burn for a while, but the carbonic acid (which is formed by the burning candle in the same manner as it is by a breathing person) being heavier cannot rise against gravity and escape at the windows, and hence settles down at the floor, and just as soon as it fills the room to the height of the blaze in the candle, the light begins to turn blue, flickers, and finally dies from carbonic acid poisoning.

Again, if I close the opening for the admission of pure air at the floor, and also the opening for the exit of foul air at the floor, and open the six windows, all at the top of the room, the candle goes out much sooner than in the previous experiment; for in this experiment the supply of fresh air is diminished as well as the escape of the car-

bonic acid prohibited, and here you see the folly and unscientific principle of opening the windows at the top to ventilate a room.

Now, if I close the windows at the top, and also the opening for the foul air at the floor, and only open the ventilator for the admission of pure air, the candle is again extinguished by the foul air which accumulates on the floor of the room, as there is no circulation of air in this case, and the poisonous gas cannot escape. Or, if I reverse this experiment, close the opening for the admission of pure air, and open the foul-air ventilator at the floor, the candle again dies from from carbon dioxide, which for want of circulation cannot escape, and the result is fatal to the candle.

It seems to me that these experiments which have been strengthened time and again by chemical analysis, are sufficient to demonstrate to any unbiased mind the fallacy of so-called top ventilation, as compared with floor ventilation. I am sure if the principles here demonstrated by this simple model were put into practice in our city schools and churches there would be fewer of our school children coming home in the evening with headache and general languor, and fewer drowsy persons in our churches during divine service than we see now, which can usually be attributed to defective ventilation and the result of a slow process of poisoning from carbonic acid, saying nothing of its effects on weak lungs and its general depression on the whole economy. For let us remember before we close, what we said at the beginning of this lecture—that pure air is one of the three essential compounds for the support of human life.

Mansfield, Ohio, Feb. 11, 1889.